

ES&H manual

Environment, Safety, and Health

Volume II

Part 14: Chemical

14.2

LLNL Chemical Hygiene Plan for Laboratories

(Formerly H&SM Supplement 21.01)

Recommended for approval by the ES&H Working Group

Approved by: Robert W. Kuckuck
Deputy Director for Operations

New document or new requirements

Approval date: June 14, 2000

Minor revision, no new requirements

Approved by: The Hazards Control Department
Approval date: August 18, 2002

DISCLAIMER

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

This work performed under the auspices of the U.S. Department of Energy by University of California Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.

14.2

LLNL Chemical Hygiene Plan for Laboratories^{*}

Contents

1.0 Introduction	1
2.0 Hazards.....	2
3.0 Procedures and Standard Work Practices	3
3.1 Work Planning.....	3
3.1.1 Development of Integration Work Sheet.....	3
3.1.2 Selection of Personal Protective Equipment and Completion of Hazard Assessment and Control Form	3
3.1.3 Development of Safety Plans.....	3
3.1.4 Conduct of Prestart Review	3
3.1.5 Authorization of Work	4
3.2 Standard Work Practices.....	5
3.2.1 General Safety-related Practices.....	5
3.2.2 Process for Chemical Selection.....	6
3.2.3 Hazard Identification	6
3.2.4 Personal Protective Equipment.....	7
3.2.5 Control of Emissions to the Environment	7
3.2.6 Prevention of Spills and Accidents.....	7
3.2.7 Storage Practices.....	8
3.2.8 Disposal of Waste.....	9
3.2.9 Termination of Work	10
4.0 Determining and Implementing Control Measures to Reduce Worker Exposure to Hazardous Chemicals.....	10
4.1 Types of Controls	10
4.2 Selection of Controls.....	11
5.0 Ensuring Performance of Fume Hoods and Other Protective Equipment.....	11
6.0 Worker Information and Training.....	12
6.1 Required Information.....	12
6.2 Required Training.....	13
7.0 Preapproval of Operations.....	13
8.0 Medical Consultation and Examination	14
9.0 Designation of Chemical Hygiene Officer.....	15
10.0 Additional Protection for Particularly Hazardous Substances	15

^{*} Minor revision

11.0 Responsibilities.....	18
11.1 Workers	18
11.2 Responsible Individual.....	18
11.3 Hazards Control.....	19
11.3.1 Chemical Hygiene Officer.....	19
11.3.2 ES&H Team.....	19
11.3.3 ES&H Team Industrial Hygienists	19
11.3.4 Safety Programs Division.....	19
11.4 Facility Managers and Facility Points of Contact.....	19
11.5 Assurance Manager	20
11.6 Associate Director	20
12.0 Work Standards.....	20
12.1 Work Standards.....	20
12.2 Other Required Standards	21
13.0 Resources for More Information.....	21
13.1 Contacts	21
13.2 Applicable Lessons Learned.....	21
13.3 Other Sources.....	21

Appendices

Appendix A Terms and Definitions	22
Appendix B Safe Practices and Procedures for Working with Chemicals.....	29

Table

Table 1. Substances addressed by OSHA substance-specific regulations.....	17
---------------------------------------------------------------------------	----

14.2

LLNL Chemical Hygiene Plan for Laboratories

1.0 Introduction

The LLNL Chemical Hygiene Plan for Laboratories is required by Occupational Safety and Health Administration (OSHA) standard 29 CFR 1910.1450, "Occupational Exposure to Hazardous Chemicals in the Laboratory" (see also 29 CFR 1910.1450, Appendices A and B). This regulation (referred to herein as the OSHA laboratory standard) addresses occupational exposure to hazardous chemicals in laboratories. As such, it complements, replaces, or supersedes other OSHA requirements regulating the control of hazardous substances.

This document contains

- The LLNL Chemical Hygiene Plan for facilities based on OSHA regulations.
- Responsibilities for complying with the OSHA laboratory standard.
- Appendix A, which contains the terms and definitions used in this document.
- Appendix B, which is nonmandatory guidance unless noted otherwise.

Where chemicals are used in laboratories, specific details for implementing this Chemical Hygiene Plan shall be included in the Facility Safety Plan (FSP). Specific details about individual procedures may be covered in Operational Safety Plans (OSPs). By reference, all parts of the LLNL *Environmental, Safety, and Health (ES&H) Manual* are part of the LLNL Chemical Hygiene Plan.

The OSHA laboratory standard only applies to laboratory workplaces where chemicals are used in a nonroutine, nonproduction manner by workers with at least some education and training in science. Examples of locations this standard applies to at LLNL include chemistry, material science, and biology research laboratories. Workplaces *not* covered by this standard include photography laboratories, electronics laboratories, machine shops, craft shops, and pilot plant operations that are or simulate a production operation.

Laboratory use of hazardous chemicals is defined as the handling or use of hazardous chemicals in which all of the following criteria are met:

- Procedures using chemicals are carried out on a laboratory scale (e.g., using containers for chemical reactions, transfers, and other handling that are easily manipulated by one person).
- Multiple chemical procedures or chemicals are used.

- The operations involved are neither part of a production process nor simulate one.
- Protective laboratory practices and equipment are available and are commonly used to minimize the potential for worker exposure to hazardous chemicals.

When the operations in a particular facility meet all of the above criteria, that facility shall comply with the requirements of this Chemical Hygiene Plan. Operations in facilities that use hazardous chemicals but do not meet the criteria previously outlined shall comply with Document 10.2, "LLNL Health Hazard Communication Program," in the *ES&H Manual* and all other applicable Work Smart Standards.

This document applies only to chemical hazards in laboratories; nonchemical health hazards—such as biological, ergonomic, and physical agent hazards—shall be addressed in accordance with Document 10.2. Carcinogens are addressed in Document 14.12, "Safe Handling of Chemical Carcinogens," in the *ES&H Manual*.

Personal protective equipment shall be selected and used in accordance with Document 11.1, "Personal Protective Equipment," in the *ES&H Manual*. The Respirator Services Team at the Hazards Control Department has developed procedures governing the issue and use of respirators because regulations affecting the design and use of respirators are in a state of flux and will be for the duration of this revision of the Chemical Hygiene Plan. Contact your ES&H Team for information about respirators.

2.0 Hazards

Laboratory hazards cover virtually every type of occupational safety and health hazard known. LLNL implements the safety practices in this Chemical Hygiene Plan to minimize exposures to a broad range of relatively small quantities of chemicals. This Chemical Hygiene Plan was written to

- Help workers avoid hazards specifically associated with chemicals.
- Protect workers from the health hazards associated with hazardous chemicals in that laboratory.
- Keep exposures below the limits specified in Work Smart Standards.

The controls for chemical hazards are described in Sections 3–10.

3.0 Procedures and Standard Work Practices

3.1 Work Planning

3.1.1 Development of Integration Work Sheet

The experimenter develops an Integration Work Sheet (IWS) for the proposed work activity. The IWS describes the scope, location, duration, hazards, and controls to mitigate the hazards of the work and is used as an authorization for projects involving work not commonly performed by the public.

3.1.2 Selection of Personal Protective Equipment and Completion of Hazard Assessment and Control Form

A Hazard Assessment and Control (HAC) form shall be used to define any required personal protective equipment (PPE) or for any use of respirators. The authorizing organization determines whether the proposed work is covered by a governing safety plan, other documentation, or if a safety plan or other documentation is needed.

3.1.3 Development of Safety Plans

Operational Safety plans or IWSs shall be developed to satisfy parts of this Chemical Hygiene Plan, and their content shall be consistent with this document. FSPs shall be the primary documentation describing how facilities shall implement this plan.

Relevant operating procedures and guidance in the *ES&H Manual* are found in the Section 13.3, Other Sources, at the end of this document.

3.1.4 Conduct of Prestart Review

Work may not begin until all controls are in place, a prestart review is conducted, and the work is authorized with facility management concurrence. The authorizing individual determines the level of formality required for the prestart review using a graded approach. The purpose of the prestart review is to ensure all of the following:

- The hardware and tools are available.
- The facility is operable, and the equipment is ready.
- The required safety systems are operable, and personnel are trained in their use.

- ES&H documentation is complete, permits are issued, and maintenance of safety systems is scheduled.
- Personnel know their responsibilities and are trained and certified, if needed, for the operation.

The prestart review may be attended by the Responsible Individual, the Responsible Individual's supervisor, the facility point of contact or facility manager, Assurance Office personnel, appropriate representatives of the ES&H Team, the building coordinator, and others, depending upon the formality of the review.

The Responsible Individual in the authorizing organization, the facility point of contact or facility manager, and the ES&H Team review the IWS to determine that the hazards have been identified and analyzed and that controls are in place. The environmental analyst on the ES&H Team addresses environmental issues, including National Environmental Policy Act (NEPA) compliance, permitting requirements, hazardous and radioactive waste generation, and waste minimization opportunities. Other members of the ES&H Team determine if safety and health issues are adequately addressed. Additional review may be needed to evaluate technical safety requirements (e.g., Engineering Safety Notes for pressure vessels).

3.1.5 Authorization of Work

The facility point of contact or facility manager advises the authorizing individual if there are facility issues (e.g., facility safety envelope, compatibility of experiments) that need to be addressed before work can be authorized. Facility modifications require approval from the facility manager before work can begin.

Experimenters are responsible for ensuring that personnel working on their projects understand and are familiar with

- The ES&H controls for the work being conducted under the IWS.
- Any relevant safety plan.
- Relevant parts of the *ES&H Manual*.

After ensuring all controls are in place by conducting a prestart review, and after obtaining concurrence from the facility point of contact or facility manager and the ES&H Team leader, the authorizing individual allows the operation to proceed.

Requirements for conducting an ES&H evaluation of planned work and obtaining an authorization to proceed are described in Appendix B of Document 2.2, "Managing ES&H for LLNL Work," in the *ES&H Manual*.

3.2 Standard Work Practices

All workers shall follow standard work practices when handling hazardous materials. These standard work practices include general safety-related practices, process for chemical selection, hazard identification, selection and use of PPE, control of emissions to the environment, prevention of spills and accidents, storage practices, disposal of waste, and termination of work. Additional recommendations to supplement these requirements are given in Appendix B.

3.2.1 General Safety-related Practices

Some general safety-related practices are listed below:

- *Never* perform hazardous operations alone in a laboratory or chemical storage area.
- Wear appropriate eye protection and PPE at all times. It is noted that contact lenses are allowed in laboratories provided they are worn under safety eyewear that meets the requirements of ANSI Z87.1 or full facepiece respirators.
- Minimize exposure to all chemicals regardless of how familiar they are to you. Because most laboratory chemicals have not been thoroughly tested for safety, their toxicity cannot be fully understood. Therefore, it is prudent to implement procedures that will reduce the likelihood of exposure. Skin contact shall be avoided.
- Assume that unknown materials are toxic and that a mixture is more toxic than its most toxic component.
- Ensure that sources of ignition are not close or nearby when working with flammable materials. This will prevent a fire or explosion if a vapor release or liquid spill occurs.
- Use a tip-resistant shield for protection in case an explosion or implosion occurs.
- Do not apply cosmetics, eat, drink, use tobacco products, or store any of these in laboratories.
- Do not use mouth suction for pipetting or starting suction.

3.2.2 Process for Chemical Selection

Before a chemical is selected for use in an operation or process, the Responsible Individual identified in the OSP or IWS shall do the following:

- Review the potential hazards of the substance, including carcinogens, to assess the conditions under which the chemical will be used. See Document 14.12 for information about carcinogens.
- Determine if disposal options exist for the chemical.
- Determine if safer alternatives are available.

The conditions in a laboratory at the time the process is being carried out shall be considered in accordance with the first three functions of Integrated Safety Management (plan the work, identify the hazards, and select the controls) before selecting a chemical for use in a procedure. The following shall be considered:

- Presence of incompatible chemicals.
- Adequacy of the ventilation or control system.
- Presence of individuals during a high-risk operation.
- Storage arrangements.
- Other conditions that may interfere with the precautions necessary for a substance or procedure.

3.2.3 Hazard Identification

Labels on incoming containers shall not be removed or defaced. Label secondary containers. Use of formulas, codes, numbers, or symbols is encouraged for marking small containers in laboratories where everyone is familiar with the marking system.

When the health effects of a chemical developed within a laboratory are unknown, that chemical shall be treated as a particularly hazardous substance (see Appendix A, Terms and Definitions).

If a laboratory produces a chemical for a nonlaboratory user, then the producer is required to comply with the labeling and material safety data sheet (MSDS) provisions of Document 10.2.

MSDSs shall be accessible to chemical users in research laboratories but need not be physically present in the area. Work supervisors and workers can obtain MSDSs for specific materials by calling the MSDS hotline (ext. 4-4404), by sending an e-mail message (msds@llnl.gov), sending a fax (ext. 3-9027) to the MSDS coordinator, or by

completing a MSDS Request Form and mailing it to MSDS, L-633. MSDSs can also be obtained from the following Internet address:

<http://ctmsds.llnl.gov:1650/livehtml/MSDS/MSDS1.html>

Work supervisors who receive hazardous materials (e.g., blanket orders, gifts) directly from outside sources should request the MSDS and forward a copy to the MSDS coordinator at L-633 for filing.

There are several regulations that specify when a laboratory is required to keep detailed chemical inventories. For the most current requirements, contact the ES&H Team leader.

3.2.4 Personal Protective Equipment

Given the nature of Laboratory operations, it is often necessary to use PPE (see Document 11.1 for more information about selecting and using PPE). HAC forms shall be prepared on the use of PPE, such as eye, skin, and body protection if not specified in the governing Safety Plan. A HAC shall be prepared for any use of respirators.

Eye protection shall be worn by all persons, including visitors, in areas where hazardous chemicals are being handled. The appropriate clothing that shall be worn for a particular process depends on the activity being carried out and the circumstances under which it is being carried out. See the governing safety plan or IWS for more specific details.

Appropriate gloves shall be worn when there is a potential for contact with toxic or corrosive materials. Gloves shall be inspected for holes, blisters, swelling, discoloration, and cracking before use and should be replaced periodically or when damaged or punctured.

3.2.5 Control of Emissions to the Environment

The Responsible Individual shall review operations for all potential emissions of hazardous materials to the environment. The ES&H Team environmental analyst will help determine if any environmental controls are needed or if any permits are required.

3.2.6 Prevention of Spills and Accidents

Spill control materials shall be available in laboratories or clusters of laboratories so personnel can clean up small spills promptly. The most common kits are spill control kits for flammable/combustible organic materials, acids (other than hydrofluoric acid), caustics, mercury, and hydrofluoric acid. These kits shall be inspected annually to assure that they are complete and to assure that parts that can deteriorate with time, such as goggle straps, are found and repaired or replaced. Larger quantities of spill control materials should be pre-positioned to allow quicker response to large spills (i.e.,

where the quantity of spilled material exceeds the amount two workers can handle in one hour). Contact your ES&H Team for guidance about spill control materials.

Respond promptly to all spills and accidents involving any hazardous chemical. Also, notify the area ES&H Team whenever an accident or spill occurs, and call the Fire Department (dial 911 at the Livermore site and at Site 300) when any of the following occurs or when in doubt about the severity of the incident:

- An accident or spill involving hazardous material results in personnel injury.
- Hazardous material is released to the sewer system.
- Area personnel are unfamiliar with the hazards of the spilled material.
- The spilled material exceeds the amount two workers can handle in one hour or if additional assistance or supplies are needed to contain and clean up the material.

First-aid measures specified below shall be followed:

- **Eye contact**—Flush eyes promptly with water for 15 min or until the victim is taken for medical evaluation.
- **Skin contact**—Flush the affected area promptly with water and remove any contaminated clothing; seek medical attention if the symptoms persist. Situations requiring safety showers/eyewashes and administrative requirements for safety showers/eyewashes are specified in Section 3.6 of Document 14.1, "Chemicals," in the *ES&H Manual*. Requirements for the testing and inspection of safety showers/eyewashes are specified in Section 3.6.3 of Document 14.1. Engineering specifications are found in Appendix A of Document 42.1, "Management of Facility Design and Construction," in the *ES&H Manual*. Persons who could use the equipment shall be advised of its location and how it is used as part of the on-the-job training.

Spills and leaks shall be promptly cleaned up if they are not emergencies and do not require the presence or assistance of the Fire Department. Use the appropriate protective apparel, equipment, and disposal procedures.

For more specific details on incident responses, refer to the substance MSDS.

Note: If a worker is sent to the Health Services Department, he/she should be accompanied with a copy of the MSDS or, if it's not available, the identity of the spilled material.

3.2.7 Storage Practices

The primary concerns about storing chemical materials are to minimize the amounts stored, avoid contact between incompatible chemicals, and ensure that hazardous storage conditions (e.g., light and heat) are not present. Specific storage procedures,

however, will depend on the type of storage facility and the chemicals in use. Below are some standard storage practices.

- Do not store incompatible materials in the same cabinet. Acids, bases, flammables, oxidizers, and poisons are mutually exclusive categories. When a substance has multiple hazards, preference shall be given to the most acute or reactive property.
- Do not store food and chemicals in the same refrigerator. Label refrigerators dedicated to chemical storage.
- Periodically check the container, label integrity, and the shelf-life expiration date of chemicals in storage. If deficient, these containers shall be correctly labeled before removing them from storage areas.
- Do not store combustible packaging materials (e.g., cardboard) in a flammable-liquid storage cabinet.
- Do not exceed the manufacturer's rated capacity for storage cabinets.
- Store only the amount of materials needed for the near future (e.g., 3 months).
- Consider the technical requirements and implement seismic safety for chemical storage rooms, shelves, and cabinets.

For more information on storing hazardous chemicals, see Document 14.1. See *Standard for Storing and Using Peroxidizable Organic Chemicals* for information about storing peroxidizable substances.

<http://www-r.llnl.gov/tid/lof/documents/pdf/235534.pdf>

3.2.8 Disposal of Waste

To protect the environment and the safety and health of all people, hazardous waste shall be disposed of properly. Therefore, all laboratory workers who generate or handle hazardous, radioactive, or mixed waste shall take course EP0006, Hazardous Waste Handling Practices. The procedures learned in this course, including those described in the *ES&H Manual*, shall be followed in laboratory workplaces.

Workers shall adhere to the disposal requirements listed below:

- Do not pour hazardous or radioactive chemicals down a sanitary sewer. Retention system drains may be used only when specifically approved for such chemicals.

- Place all wastes in the proper containers for disposal. Waste shall be removed from laboratories in accordance with Document 36.1, "Waste Management Requirements," in the *ES&H Manual*.
- Before vacating a laboratory, ensure that the chemicals and wastes you are responsible for are properly labeled, prepared for disposal, or assigned to someone who understands how to manage such materials. See Document 12.7, "Shutdown or Transfer of Facilities, Operations, or Associated Equipment," in the *ES&H Manual* for more information.

3.2.9 Termination of Work

The Responsible Individual notifies facility management and the ES&H Team when the work is terminated and, if applicable, when required decontamination and decommission is complete. Unless the decontamination and decommissioning are included in the original IWS, that process will require a separate IWS.

4.0 Determining and Implementing Control Measures to Reduce Worker Exposure to Hazardous Chemicals

The purpose of this section is to provide the framework for selecting control measures for minimizing the risk of chemical hazards. Given the enormous variety of hazardous materials and potential operations, it is not possible to specify here the safety practices needed for every possible situation (see Document 2.2 for more information about work planning). The guidelines that follow shall be considered when planning controls for operations.

4.1 Types of Controls

Chemical hazards are reduced through a combination of control measures to minimize exposure. These measures include the following (in order of preference):

- Chemical substitution—using a less hazardous compound.
- Engineering controls—containments, enclosures, ventilation systems, and facility design. Ventilation is more effective and often more economical when combined with containment.
- Work process selection—selecting processes like heating, aerosolization, or pulverizing that avoid making a material more dispersible.
- Administrative controls—written safety documentation, training, and limiting access.

- Personal protective equipment—respirators, gloves, and chemical protective clothing.
- Work practices—personal hygiene, effective use of hoods and other engineering controls, and laboratory technique.

4.2 Selection of Controls

After analyzing the job hazards, a combination of controls may be used based on the following factors:

- The inherent toxic and physical properties of the materials, the processes they will be subjected to, and their intended use.
- The possibility of unplanned outcomes, spills, and accidents.
- Workplace factors, such as existing ventilation and protective systems.
- Possible exposure routes (e.g., inhalation, skin or eye contact, or ingestion).
- Worker skills, training, and prior experience.

Consultation with program management and the ES&H Team is usually necessary before selecting the final control measures. This is especially true for new operations and those that involve particularly hazardous substances (see Section 10.0, Additional Protection for Particularly Hazardous Substances).

5.0 Ensuring Performance of Fume Hoods and Other Protective Equipment

Specific measures shall be taken to ensure proper and adequate performance of fume hoods and other protective equipment, including alarm systems. The requirements in Document 12.2, "Ventilation," in the *ES&H Manual* and its associated documents shall be followed. These documents include ventilation requirements and acceptance criteria for all new and modified facilities, as well as surveillance, maintenance, and system-failure procedures for existing facilities. Consult with the Plant Engineering Department and the ES&H Team before making a change to existing systems. Plans for new ventilation systems shall be made based on agreements among departmental, Plant Engineering or other design group, and the area ES&H Team before resources are allocated and the formal review process is started.

Hoods shall not be used for storage unless concurred by the area ES&H Team. Work supervisors shall ensure that

- The bottom slot is not blocked off by containers or apparatus. If possible, bottles and equipment should be perched on raised shelves so air can reach the bottom slot.
- The top slot is open when heat sources, including Bunsen burners, are used in the hood.
- Articles are placed no closer than six inches from the hood face, whenever practical, and the hood is smoke tested (see Appendix A, Terms and Definitions) if articles must be closer.
- Workers do not place their heads inside of hoods unless appropriate precautions are taken.

6.0 Worker Information and Training

Workers shall receive the training that will enable them to work safely. This training shall be conducted and documented in accordance with Document 40.1, "LLNL Training Program Manual," in the *ES&H Manual* and the training plan for each directorate.

6.1 Required Information

The Responsible Individual shall provide workers with the following:

- Location of hazardous chemicals in the work area at the time of initial assignment and before each new assignment that involves chemicals to which the worker may be exposed.
- Permissible exposure limits (PELs) or the threshold limit values (TLVs) for any OSHA-regulated substance used in the worker's job assignment. For a list of the most current PELs and TLVs, contact the area ES&H Team.
- Information on the effects, signs, and symptoms of exposure to any hazardous substance being used.
- Location and availability of standard reference materials on the hazards found in the individual laboratories, including safe handling, storage, and disposal procedures for those hazardous chemicals.
- Location of the OSHA laboratory standard (29 CFR 1910.1450); see
http://www.osha-slc.gov/OshStd_data/1910_1450.html
 If necessary, contact the ES&H Team for a copy of this standard.
- Location of this Chemical Hygiene Plan.

6.2 Required Training

The training required by this Chemical Hygiene Plan shall include the following:

- Methods and observations used to determine the presence or release of a hazardous chemical, such as monitoring conducted by the Hazards Control Department, continuous monitoring devices, and the visual appearance or odor of hazardous chemicals being used. Many organic vapors can be monitored easily using vapor dosimeters, which are light weight, are completely passive, and have no heavy and inconvenient pumps. Contact your area health and safety technician or industrial hygienist to arrange for exposure monitoring.
- Measures that workers can take to protect themselves from hazards. These include appropriate engineering and administrative controls and personal protective equipment.
- Physical and health hazards in the work area, including flammable and reactive materials, irritants and corrosives, acute poisons, chronic organic toxins, allergens, and genetic toxins.
- MSDSs and their contents.
- Proper labeling, storage, and waste-disposal practices.
- Applicable details of this Chemical Hygiene Plan (i.e., the individual elements and its availability).

This training can be accomplished through formal courses given by the Environmental Protection Department and the Hazards Control Department, informal on-the-job training, or both.

The frequency for refresher training is not stipulated in the OSHA regulation; therefore, departments and divisions are encouraged to evaluate the need for such training on a case-by-case basis and in accordance with other ES&H training in their directorate's training plan.

7.0 Preapproval of Operations

The governing FSP lists the categories of work that may be performed in each facility, those that require prior review, and those that require a supplemental OSP. The Responsible Individual shall review the FSP as part of the IWS process to ensure that they are within the scope of the FSP. Operations that are not within the scope of the FSP shall be evaluated in accordance with Document 2.2.

8.0 Medical Consultation and Examination

Medical attention following an exposure to chemicals is provided through the Health Services Department. Consultation, examination, and treatment by licensed physicians and nurse practitioners are available to all workers. In the event of a known acute exposure, referral should be prompt to ensure that appropriate decontamination and medical care are provided on time.

Workers shall be referred to the Health Services Department if

- Signs or symptoms develop that may be related to handling a chemical (e.g., headaches, skin rashes, dizziness, nausea, or loss of coordination or motor control). A relationship shall be considered possible until appropriate evaluation indicates otherwise.
- Air monitoring indicates concentrations of contaminants exceed the PEL or TLV.
- An event such as a spill, leak, or explosion results in a hazardous exposure.

Medical attention includes

- Evaluation of medical history and examination.
- Specific treatment as necessary.
- Laboratory tests, if required.
- Follow-up examination.

If a worker is referred to the Health Services Department for medical consultation or examination, management shall provide the physician with:

- The name and nature of any chemical that may be involved (including the MSDS if one is available).
- The conditions under which any possible overexposure occurred.
- Any monitoring or test results.
- A report of any signs or symptoms the worker or management has identified.

The Health Services Department examiner shall provide a written report to the worker's manager identifying

- Medical follow-up, if needed.
- The results of the medical examination and any associated tests.
- Any medical condition identified during the examination that may place the worker at increased risk as a result of exposure to hazardous chemicals found in the workplace.

- A statement that the worker has been informed by a physician of the results of the examination and of any medical condition that may require further examination or treatment.

Note: This report should not include specific findings of diagnoses unrelated to occupational exposure.

The Health Services Department only provides emergency and first-aid care to contract labor, contractors, consultants, and other non-LLNL workers. These individuals shall then be referred to their company's physician or private practitioner for further treatment, if necessary. Management shall provide the contractor's physician with the chemical names and the condition of exposure, as previously described.

9.0 Designation of Chemical Hygiene Officer

The Hazards Control Department shall appoint a chemical hygiene officer for the Laboratory.

10.0 Additional Protection for Particularly Hazardous Substances

Special consideration shall be given to protecting workers from particularly hazardous chemicals. For the purposes of this document, these include materials listed in the LLNL-Controlled Carcinogen List for Laboratories described in Document 14.12, reproductive hazards, and acutely toxic materials (see Appendix A for definitions). The list of particularly hazardous chemicals shall be reviewed annually. For a current copy of this list, contact the ES&H Team.

The precautions used to protect workers from exposure to particularly hazardous chemicals shall be specified by the IWS or one of its reference documents (FSP or OSP). Document 14.12 provides requirements and guidance for the safe handling of carcinogens and may be used as a recommended guide for handling other highly hazardous chemicals. Document 12.4, "Work Enclosures and Local Exhaust Systems for Toxic and Radioactive Materials," in the *ES&H Manual*. Document 12.4 provides safety requirements for using hoods and glove boxes when toxic materials are handled.

When particularly hazardous substances are used in laboratories, the controls below shall be implemented for additional protection. It is strongly recommended that the area ES&H Team be contacted for assistance with identifying which substances are particularly hazardous and for guidance on selecting controls.

- Establish designated areas (defined in Appendix A). The facility manager (or his/her designee) shall ensure that the appropriate warning signs are posted in these areas. The following signs are acceptable:
 - Custom-printed signs printed by the Hazards Control Department.
 - Commercially available signs.
 - For operations lasting two days or less, a piece of paper with large nondissolving print advising what type of hazard is present.
- Use containment devices (e.g., fume hoods or glove boxes) when
 - Volatilizing or aerosolizing listed substances or substances with an OEL below 50 ppm.
 - Using laboratory procedures that may result in an uncontrolled release of the substance.

High-efficiency particulate air (HEPA) filters, carbon beds, or scrubber systems shall be used with containment devices to protect effluent and vacuum lines, pumps, and the environment whenever feasible.

- Establish procedures for the safe removal of contaminated waste. Disposal of any of the substances identified in this section is controlled by state or local regulations. If necessary, refer to Document 36.1 for removal and disposal policies and guidelines, or contact the area ES&H Team environmental analyst for guidance.
- Develop decontamination plans. To ensure that chemical residues do not remain on the body, clothing, or equipment, workers shall follow the protocols in the safety plan, IWS, or HAC upon completing work with particularly hazardous substances or in the event of accidental contact with such chemicals.
- Inform workers of the hazards in designated areas. Ensure that workers who work in designated areas are authorized to do so, and that they are trained on how to handle the hazards in such areas. All chemical safety training provided to workers shall be documented in accordance with Document 40.1.
- Ask the ES&H Team to conduct air- and surface-contamination monitoring for new procedures or when working conditions have changed.

Note: Surface-contamination monitoring and fixed-location air sampling provide supporting information that supplements the primary information gained by worker breathing zone air sampling. The results will help determine if a regular surveillance program is necessary. Initial monitoring is required if the materials listed in the left column of Table 1 are used.

Exposure monitoring is not needed if

- Exposure to airborne material is precluded by extremely reliable means without using PPE or operation-specific administrative controls.
- Air sampling of the same operation elsewhere at LLNL shows airborne concentrations cannot exceed the action level for the contaminant.

If the materials in the right hand column of Table 1 are used in a laboratory, the work practices and facilities shall be reviewed. Contact the your area ES&H Team for monitoring and review assistance.

Table 1. Substances addressed by OSHA substance-specific regulations.^a

Substances requiring exposure monitoring	Substances that <i>do not</i> require air monitoring
Acrylonitrile	2-Acetylaminofluorene
Arsenic, inorganic	4-Aminodiphenyl
Asbestos ^b	Benzidine
Benzene	Bis(chloromethyl) ether
1,3-Butadiene	3,3'-Dichlorobenzidine (and its salts)
Cadmium	4-Dimethylaminoazobenzene
Coal tar pitch volatiles ^c	Ethyleneimine
1,2-Dibromo-3-chloropropane	Methyl chloromethyl ether
Ethylene oxide	1-Naphthylamine
Formaldehyde	2-Naphthylamine
Lead ^d	4-Nitrobiphenyl
Methylene chloride	N-nitrosodimethylamine
4,4'-Methylene dianiline	
Vinyl chloride	
2-Propiolactone ^e	

^a OSHA requires exposure monitoring for the substances in the first column but not for the substances in the second. For more details about these substances, contact the area ES&H Team or refer to 29 CFR 1910.1001–1048. The substances in the second column and 2-Propiolactone in the first column are addressed by 29 CFR 1910.1003.

^b Document 14.9, "Safe Handling of Asbestos-Containing Material," in the *ES&H Manual* contains guidance about asbestos.

^c Coal gasification, oil-shale research, and burning of gun propellants in vacuum have similar chemistry.

^d Document 14.10, "Safe Handling of Lead and Lead Compounds in General Industry and Construction Operations," (in the *ES&H Manual* contains guidance about lead.

^e OSHA did not establish a PEL for this substance, but an American Conference of Governmental Industrial Hygienists (ACGIH) TLV for it was subsequently adopted.

11.0 Responsibilities

The responsibilities for each person and organization with regard to the Chemical Hygiene Plan are listed under each title in this section. Overall health and safety responsibilities are specified in Document 2.1, "Laboratory and ES&H Policies, General Worker Responsibilities, and Integrated Safety Management," in the *ES&H Manual*.

11.1 Workers

Workers shall conduct each task (experiment) in accordance with the applicable controls identified in the IWS and its reference documents.

11.2 Responsible Individual

LLNL refers to the person who has primary line responsibility for ES&H in laboratories as the Responsible Individual.

The Responsible Individual's primary chemical hygiene duties include

- Identifying the need for developing safety plans and IWSs for each experiment.
- Being familiar with this Chemical Hygiene Plan and its applicability to his/her operations.
- Ensuring that all project personnel have been informed and trained on the work they are assigned, as required by Section 6, Worker Information and Training, of this plan.
- Evaluating the project's potential for environmental emissions.
- Reviewing and understanding planned experimental activities, the hazardous chemicals involved, and special personal protective equipment that may be required for those activities.
- Assuring that workers working within the laboratory know and follow the directorate's chemical hygiene plan (e.g., the FSP) for their work area.
- Assuring that proper protective equipment is available and is in working order, and that the assigned staff has been trained in the proper use of such equipment.
- Knowing the operating limits of the FSP and when to prepare OSPs.
- Making periodic, informal chemical safety and housekeeping inspections and initiate corrective action where necessary.

11.3 Hazards Control

11.3.1 Chemical Hygiene Officer

- Provide technical guidance and assistance to all directorate organizations in implementing this Chemical Hygiene Plan.
- Prepare and maintain a list of particularly hazardous substances. Review list of particularly hazardous materials annually and update as needed.
- Review and evaluate the effectiveness of the overall Chemical Hygiene Plan annually.
- Review and evaluate how effectively LLNL authorizing organizations implement the plan.
- Recommend updates to the plan as necessary.

11.3.2 ES&H Team

- Provide support including workplace monitoring, preparing HACs, providing training, and recommending controls to minimize exposure and emissions to the environment.

11.3.3 ES&H Team Industrial Hygienists

- Provide day-to-day guidance on issues related to chemical hygiene and safety.
- Coordinate activities related to the Chemical Hygiene Program with the Laboratory's chemical hygiene officer.

11.3.4 Safety Programs Division

- Appoints the Laboratory Chemical Hygiene Officer in accordance with Section 9 of this document.

11.4 Facility Managers and Facility Points of Contact

All facility managers and facility points of contact shall be familiar with the contents and objectives of this Chemical Hygiene Plan and shall assure the appropriate implementation of its requirements.

11.5 Assurance Manager

- Be familiar with this Chemical Hygiene Plan.
- May review and monitor implementation of elements of the plan within the directorate organization.

11.6 Associate Director

- Determine which part of his/her operations is governed by the OSHA laboratory standard, and ensure that such operations comply with this Chemical Hygiene Plan.
- Have ultimate responsibility for ES&H related to operational precautions.
- Ensure that the management chains periodically assess their implementation of the Chemical Hygiene Plan.

12.0 Work Standards**12.1 Work Standards**

29 CFR 1910 Subpart H, "Hazardous Materials" (contains 29 CFR 1910.109[a], "Explosives and Blasting Agents").

29 CFR 1910 Subpart Z, "Toxic & Hazardous Substances" (contains 29 CFR 1910.1450, "Occupational Exposure to Hazardous Chemicals in the Laboratory"). This includes standards for which there is a medical surveillance requirement.

ACGIH *Industrial Ventilation Manual*, 1998.

ANSI Z9.5-1992, "Laboratory Hood Ventilation," Sections 5.7 and 5.8.

ANSI Z358.1, "American National Standard for Emergency Eyewash and Shower Equipment" (except that testing frequency shall be monthly), 1990.

DOE Order 440.1A, "Worker Protection Management for DOE Federal and Contractor Employees," Attachment 2, "Contractor Requirement Document," Sections 1–11, 1318 (delete item 18.a), 19 (delete item 19.d.3) and 22.

NFPA 45, "Standard on Fire Protection for Laboratories Using Chemicals."

Occupational Medicine Standard for Medical Evaluation of Employees, Lawrence Livermore National Laboratory, Livermore, California, UCRL-AR-129189, 1999.

12.2 Other Required Standards

Kelly, R., and G. Miller, *Standard for Storing and Using Peroxidizable Organic Chemicals*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-AR-133218 Rev 1, 1999.

13.0 Resources for More Information

13.1 Contacts

See the ES&H contact list.

13.2 Applicable Lessons Learned

The Lessons Learned Program is available on the Internet at the following URL address:

http://www.llnl.gov/es_and_h/lessons/lessons.shtml

13.3 Other Sources

American Chemical Society, *Safety in Academic Chemistry Laboratories*, American Chemical Society, Washington, D.C. (1995).

California, State of, "List of Reproductive Hazards," *Proposition 65* (latest revision—updated every 6 months).

Furr, A., *Handbook of Laboratory Safety*, Fourth edition. Published by CRC Press, Boca Raton, Florida (1995).

International Agency for Research on Cancer, "Group 1—Carcinogenic to Humans," in *IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man*, World Health Organization Publications Center, Albany, New York (latest editions). Available as a link from the ChemTrack MSDS site.

National Research Council, *Prudent Practices for Handling Hazardous Chemicals in Laboratories*. Published by National Academy Press, Washington, D.C., 1981.

Shepard, T.H., *Catalogue of Teratogenic Agents*, Sixth edition. Published by Johns Hopkins Press, Washington, D.C., 1989.

Document 40.1, "LLNL Training Program Manual," in the *ES&H Manual*.

U.S. Department of Health and Human Services, National Toxicology Program, *Annual Report on Carcinogens*. Published by U.S. Government Printing Office, Washington, D.C. (latest edition). Available as a link from the ChemTrack MSDS site.

Appendix A

Terms and Definitions

Action level	A concentration designated in 29 CFR 1910 Subpart Z for a specific substance. This value is calculated as an 8-h, time-weighted average and initiates certain required activities (e.g., exposure monitoring and medical surveillance) or 1/2 of the occupational exposure limit for substances not addressed by OSHA substance-specific standards.
Acute toxicity	The toxic effect of a substance that has a rapid onset, sharp or severe effects, and pronounced symptoms; this effect is not chronic.
American Conference of Governmental Industrial Hygienists (ACGIH)	An independent professional organization that prepares an annual list of recommended exposure guidelines for hazardous chemicals in the occupational setting.
Chemical hygiene plan	<p>A written program developed and implemented by the employer that sets forth procedures, equipment, personal protective equipment, and work practices to</p> <ol style="list-style-type: none"> 1. Protect workers from the health hazards caused by hazardous chemicals used in a particular workplace. 2. Meet the requirements of paragraph (e) of 29 CFR 1910.1450.
Chronic toxicity	The toxic effect of a substance that develops gradually, lasts for a long time, and may have a delayed onset after exposure; this effect is not acute.
Combustible liquid	Any liquid having a flash point at or above 100°F (37.8°C) but below 200°F (93.3°C), except for mixtures having components with flash points of 200°F (93.3°C) or higher, the total volume of which makes up 99% or more of the total of the mixture.

Compressed gas	<ol style="list-style-type: none"> 1. A gas or mixture of gases in a container that has an absolute pressure exceeding 40 psi at 70°F (21.1°C). 2. A gas or mixture of gases in a container that has an absolute pressure exceeding 104 psi at 130°F (54.4°C) regardless of the pressure at 70°F (21.1°C). 3. A liquid having a vapor pressure that exceeds 40 psi at 100°F (37.8°C), as determined by American Society for Testing and Materials (ASTM) D-323-72.
Designated area	An area that may be used for work with select carcinogens, reproductive toxins, or substances that have a high degree of acute toxicity. A designated area may be an entire laboratory, an area of a laboratory, or a device (e.g., a laboratory hood).
Emergency, chemical	<p>An incident involving chemicals that becomes an emergency whenever there is</p> <ul style="list-style-type: none"> • Personnel injury • An unplanned release to the environment • An unplanned or uncontrolled fire or explosion • Significant property damage
Explosive	A chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.
Flammable chemical	<p>A chemical that falls into one of the following categories:</p> <ol style="list-style-type: none"> 1. Aerosol, flammable—An aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flammable projection that exceeds 18 in. at the full valve opening or a flashback (a flame extending back to the valve) at any degree of the valve opening.

Flammable chemical
(cont'd)

2. Gas, flammable
 - A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13% or less by volume.
 - A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air that is more than 12% of volume regardless of the lower limit.
3. Liquid, flammable—Any liquid having a flash point below 100°F (37.8°C), except for mixtures having components with flash points of 100°F (37.8°C) or higher, the total of which makes up 99% or more of the total volume of the mixture.
4. Solid, flammable — A solid, other than a blasting agent or explosive (as defined by 29 CFR 1910.109[a]), that may (1) cause fire through friction, absorption change, or retained heat from manufacturing or processing, or (2) that can be ignited readily and, when ignited, burns vigorously and persistently, thereby creating a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than 0.1 in./sec along its major axis.

Hazardous chemical

A chemical for which there is statistically significant evidence (based on at least one study conducted in accordance with established scientific principles) that acute or chronic health effects may occur if workers are exposed. The term "health hazard" includes chemicals that are carcinogens; toxic or highly toxic agents; reproductive toxins; irritants; corrosives; sensitizers; hepatotoxins; nephrotoxins; neurotoxins; agents that act on the hematopoietic systems; or agents that damage the lungs, skin, eyes, or mucous membranes.

High acute toxicity	<p>Substances with the following effects (from 29 CFR 1910.1200):</p> <ul style="list-style-type: none"> • Median LD₅₀ of 50 mg/kg orally in albino rats, total dosage 200–300 g. • Median LD₅₀ of 200 mg/kg by continuous contact for 24 h with the bare skin of albino rabbits weighing between 2 and 3 kg. • Median LC₅₀ in air of 200 ppm (or mg/l) continuous inhalation for 1 h.
Laboratory	A facility where the laboratory scale use of hazardous chemicals occurs, or a workplace where relatively small quantities of hazardous chemicals are used on a nonproduction basis.
Laboratory scale	Work with substances in which the containers used for chemical reactions, transfers, and other handling are designed to be easily and safely manipulated by one person. Laboratory scale excludes those workplaces whose function is to produce commercial quantities of materials.
Laboratory use of hazardous chemicals	<p>The handling or use of such chemicals where all of the following conditions are met:</p> <ol style="list-style-type: none"> 1. Chemical manipulations are carried on a laboratory scale. 2. Multiple procedures or chemicals are used. 3. The procedures involved are neither part of a production process nor in any way simulate one. 4. Protective laboratory practices and equipment are available and are commonly used to minimize the potential for worker exposure to hazardous chemicals.
Lethal concentration, 50% (LC ₅₀)	Lethal concentration, 50% is the statistical calculation of the airborne level of a substance that, if inhaled, is fatal to 50% of the test organisms. This concentration is usually expressed in units of mass over volume (mg/m ³) or in parts per million (ppm). Species and exposure conditions shall be specified.

Lethal dose, 50% (LD ₅₀)	Lethal dose, 50% is the statistical calculation of the amount of a substance that is fatal to 50% of the test organisms. This value is usually expressed in units of mass per body weight of the tested species (e.g., mg/kg). Exposure route, species, and duration of exposure conditions shall be specified.
Occupational exposure limit (OEL)	The maximum concentration of an air contaminant to which working people can be exposed for a specified time interval, usually the maximum average exposure allowed throughout an entire eight-hour shift. OELs are typically PELs or TLVs, which are also defined in this appendix.
Organic peroxide	An organic compound that contains the bivalent -O-O- structure. Such a compound may be considered as a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms have been replaced by an organic radical.
Oxidizer	A chemical, other than a blasting agent or explosive (as defined in 29 CFR 1910.109[a]), that initiates or promotes combustion in other materials, thereby causing fire of itself or through the release of oxygen or other gases.
Particularly hazardous substances	For the purposes of this document, these include OSHA-select carcinogens, reproductive toxins, and substances with a high degree of acute toxicity.
Permissible exposure level (PEL)	The OSHA exposure limits for hazardous chemicals in the workplace. These limits are contained in 29 CFR 1910 Subpart Z.
Physical hazard	A chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, an explosive, flammable, an organic peroxide, an oxidizer, a pyrophoric, unstable (reactive), or water reactive.
Protective laboratory practices and equipment	Laboratory procedures, practices, and equipment accepted by laboratory health and safety experts as effective or those that workers can show to be effective in minimizing the potential for worker exposure to hazardous chemicals.

Reproductive toxins	Chemicals that affect reproductive capabilities, including chromosomal damage (mutations) and effects on fetuses (teratogenesis). For the purposes of this Chemical Hygiene Plan for Laboratories, these include any substance or exposure identified as reproductive toxins in the <i>Catalogue of Teratogenic Agents</i> and the State of California list of reproductive hazards under Proposition 65.
Select carcinogen	<p>Any substance that is</p> <ol style="list-style-type: none"> 1. Regulated by OSHA as a carcinogen. 2. Listed under the category "known to be carcinogens" in the National Toxicology Program's (NTP's) <i>Annual Report on Carcinogens</i>. 3. Listed under Group 1 (carcinogenic to humans) by the <i>International Agency for Research on Cancer (IARC) Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man</i>. 4. Listed in either Group 2A or 2B by IARC or under the category "reasonably anticipated to be carcinogens" by NTP. Such a substance causes statistically significant tumor incidence in experimental animals based on any of the following criteria: <ul style="list-style-type: none"> • After inhalation of 6–7 h per day, 5 days per week, for a significant part of a lifetime of levels less than 10 mg/m³. • After repeated skin application of less than 300 mg/kg of body weight per week. • After oral dosages of less than 50 mg/kg of body weight per day.
Smoke Test	Release of a visible aerosol to determine the direction and adequacy of air flow.
Threshold limit value (TLV)	Airborne concentrations of substances to which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse health effects.

Unstable (reactive)	A chemical that, in its pure state or as produced and transported, will vigorously polymerize, decompose, condense, or become self-reactive under conditions of shock, pressure, or temperature.
Water reactive	A chemical that reacts with water to release a gas that is flammable or a health hazard.

Appendix B

Safe Practices and Procedures for Working with Chemicals

The guidance in this appendix is advisory. It supplements the requirements in the LLNL Chemical Hygiene Plan for Laboratories, may meet the specific needs of some laboratories, and may be useful for worker training and for preparing OSPs and FSPs. (Most of the information in this appendix was taken from Appendix A of 29 CFR 1910.1450, which summarizes material from *Prudent Practices for Handling Hazardous Chemicals in Laboratories* (National Research Council 1981).

B.1 General Safe Practices

The general practices below are recommended when working with chemicals in laboratories

- Do not smell or taste chemicals.
- Vent apparatus (e.g., vacuum pumps and distillation columns) that may discharge toxic chemicals into local exhaust devices.
- Do not release toxic substances into cold or warm rooms; these rooms have contained, recirculated atmospheres.
- Handle and store laboratory glassware carefully to avoid damage; do not use damaged glassware. Use extra care with Dewar flasks and other evacuated glass apparatus; if necessary, shield or wrap them to contain chemicals and garments in case an implosion occurs. Use equipment only for its designed purpose.
- Carry particularly hazardous chemicals in secondary containers unless this compromises safety.
- Wash areas of exposed skin well before leaving the laboratory.
- Avoid practical jokes or other behavior that might confuse, startle, or distract another worker.
- Confine long hair and loose clothing. Wear shoes at all times in the laboratory; sandals or perforated shoes are not permitted.
- Properly label and store chemicals and equipment.
- Remove laboratory coats immediately after contamination.

- Keep materials stored in hoods to a minimum; do not allow materials to block vents or the air flow.
- Leave the hood on when not in use, especially if it contains toxic substances or if you are uncertain whether adequate general laboratory ventilation will be maintained when the hood is off.

Also, the work area should be kept clean and uncluttered and cleaned up upon completing an operation or at the end of each day.

B.2 Working with Chemicals of Moderate, Chronic, or High-Acute Toxicity

The precautions below are recommended when working with chemicals of moderate, chronic, or high-acute toxicity. Examples of these substances include diisopropylfluorophosphate, hydrofluoric acid, and hydrogen cyanide.

- Use all reasonable precautions to minimize exposure to these toxic substances.
- Always use a hood (that has been previously evaluated to confirm adequate performance) or other containment devices for procedures that may generate aerosols or vapors containing the substance; if possible, trap released vapors to prevent discharge.
- Always avoid skin contact with these materials; use gloves, long sleeves, and other protective apparel as appropriate. Always wash hands and arms immediately after working with these materials.
- Ensure that at least two people are present at all times if a compound in use is highly toxic or its toxicity is unknown.
- Store breakable containers with these substances in chemically resistant trays; also, operate and mount apparatus above such trays or cover work and storage surface with removable, absorbent, plastic-backed paper.

B.3 Working with Chemicals of High-Chronic Toxicity

The precautions below are recommended when working with chemicals of high-chronic toxicity. Examples of such substances include dimethylmercury and nickel carbonyl, benzo[a]pyrene, N-nitrosodiethylamine, and other human carcinogens or substances with high carcinogenic potency in animals.

- Conduct all transfers and work with these substances in a controlled area (e.g., a restricted access hood, glove box, or part of a laboratory designated for working with such substances). Ensure that all persons with access to controlled areas are aware of the substances being used and the precautions required.

- Protect vacuum pumps from being contaminated by scrubbers of HEPA filters; vent them into the hood.
- Decontaminate the controlled area before normal work is resumed.
- Remove any protective apparel and thoroughly wash hands, forearms, face, and neck before leaving a controlled area. Place the apparel in an appropriately labeled container.
- Use a wet mop or a vacuum cleaner with a HEPA filter if the toxic substance is a dry powder; do not dry sweep.
- Consult with the Health Services Department about regular medical surveillance if you often use large quantities of toxic substances.
- Ensure that the controlled area is conspicuously marked with warning and restricted access signs, and that all containers with these substances are appropriately identified and have warning labels.
- Ensure that contingency plans, equipment, and materials are available to minimize exposures to people and property if an accident occurs.
- Store chemicals in unbreakable, chemically resistant, secondary containers. Label the containers appropriately and store them in a ventilated, limited-access area.

B.4 Working with Allergens and Embryotoxins

The precautions below are recommended when working with allergens and embryotoxins.

- Review each use of these materials with the research supervisor; review continuing uses annually or whenever a procedural change is made.
- Properly label these substances; store them in an unbreakable secondary container in an adequately ventilated area.
- Notify supervisors of all incidents of exposure or spills; consult a qualified physician when appropriate.

Examples of and the requirements for these substances are as follows:

- *Allergens* (e.g., diazomethane, isocyanates, and bichromates)—Wear suitable gloves to prevent hand contact with allergens or substances of unknown allergenic activity.

- *Embryotoxins* (e.g., organomercurials, lead compounds, and formamide)—If you are a woman of childbearing age, only handle these substances in a hood that functions properly. Use appropriate protective apparel (especially gloves) to prevent skin contact.

B.5 Animal Work with Chemicals of High-Chronic Toxicity

The following precautions are recommended when animal work involves chemicals of high-chronic toxicity:

- Administer the substance by injection or gavage instead of in the diet, when possible. If the substance is administered by diet, use a caging system under negative pressure or under laminar air flow directed toward HEPA filters.
- Develop procedures that minimize the formation and dispersal of contaminated aerosols, including those from food, urine, and feces. Use HEPA-filtered vacuum equipment for cleaning, moisten contaminated bedding before removal from the cage, and mix diets in closed containers in a hood.
- Wear plastic or rubber gloves and fully buttoned laboratory coats or jumpsuits when working in the animal room. Other apparel and equipment (e.g., shoe and head coverings or respirators) may be used because of incomplete suppression of aerosols.

Note: Special facilities with restricted access are preferred for large-scale studies.